
Performance consequences on complexity in Public-private Partnerships: Evidence from Indian Highway Projects

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ABSTRACT

Public-private partnerships in the highway sector are complex organisational systems. Long term concessions, large size, multiple stake holders, and the changing environment are the source of higher complexity and have performance implications. However, despite the important development impact of PPPs, the link between complexity and performance in this context is not studied. To better understand this link we make a base level of a hypothesis that complexity has performance implications and test the same empirically.

We use a database of highway projects in India, to study the challenges in identifying the performance consequences of increased complexity. We are able to analyse 173 highway PPP projects, restricting ourselves to those which have been successfully constructed (and started commercial operation), and on which reliable data is available. We find complexity, arising from the length of the concession, to be associated with project delays. We also find direct state involvement and project size, both sources of increased complexity, to be positively associated with project cost over runs. Moving further, we review the literature on management of PPPs and identify possible moderators and mediators that could impact this link, paving the way for future research in this direction.

INTRODUCTION

Public-private partnerships (PPP) have emerged as a dominant and innovative mode for delivering public services and assets. They have emerged as an attractive option to addressing the ballooning infrastructure gaps in both the developed and developing world (Kwak, Chih, & Ibbs, 2009; Hodge, Greve, & Boardman, 2010). Straddling the public private interface, the literature on PPPs seeks to optimally allocate risks between public and private agents, in the quest for improving value for money (Grimsey & Lewis, 2001).

The PPP concept, however, is still nascent and evolving. It faces definitional issues, with numerous debates about what a PPP actually is (Hodge, Greve, & Boardman, 2010). Simultaneously, the rationale of PPP formation have been intensely debated (Hodge, Greve, & Boardman, 2010). Even the measures, aspects, perspectives and antecedents to PPP performance have been the subject of numerous debates. While various literature streams have contributed to our current understanding on PPPs (Kivleniece & Quelin, 2012), most of the literature is dominated by economic thinking, wherein the objective function lies in the identification of the optimal design of the public-private boundary through risk allocation (Rangan, Samii, & Van Wassenhove, 2006). The PPP performance is accordingly traced to the ex-ante PPP contract designs in the PPP formation stage, wherein the risk allocation is carried out (Klijn & Koppenjan, 2016).

The strive for bettering PPP performance makes the governing contractual structure into a complex and a long term arrangement, with extensive bundling of activities, and executed in a hybrid public-private setup.

This is an ex-ante view. While recognizing the incomplete nature of contracts, and the exposure of PPP to significantly large amount of environmental, political and social uncertainties over their long lifetime, this view does not emphasize study of PPPs during their implementation and operational phase, wherein both the changing risk profile and the resultant changes in complexity need to be managed.

This paper seeks to shift the focus of PPP discussion from their formation stage to their operational stage. While making this shift it is argued that the ex-ante contract mode of carrying out risk allocations adds significant complexity to PPPs (Klijn and Teisman, 2003). Focusing on the implementation stage of PPPs, it is emphasized that the implementation phase is all about management of complexity, in contrast to the management of risk that is the focus of PPPs in the formation stage.

The paper is structured as follows. A review of PPP complexity is first presented, wherein the sources and aspects of PPP complexity are discussed. To further strengthen the saliency of PPP complexity argument we carry out theory building hypothesizing about the performance implications of PPP complexity. Using a database of Indian highway PPP projects, we run some preliminary tests about the performance implications of PPP complexity and present the mixed results that we get. We next review the limited literature on PPP management and identify some key managerial aspects which are likely to moderate this important complexity performance link, and need to form the focus of future studies.

LITERATURE REVIEW

PPP projects involve external actors and are hence different from conventional infrastructure projects, not lying exclusively in the domain of project management (Shenhar & Dvir, 1996). Bundling of activities is an essential feature of public-private partnerships. By bundling of construction and operational activities the PPP's bring value as one agency can optimize the costs between the two phases, especially in situations where there is significant ambiguity in the features and characteristics which have an overlapping role between the two stages (Hart, 2003; Geyer & Davies, 2000). Also, bundling of activities (construction and financing) allows for the typically large project costs of infrastructures to be paid for over the project life cycle. However, this bundling increases the number of diverse activities requiring coordination. This is a source of increased complexity (Steijn, Klijn, & Edelenbos, 2011).

PPP are long term, as contract length is required for private partner to recover the initial investment (Hodge, Greve, & Boardman, 2010). By promising guaranteed cash flows, the private sector can make the extra investments over time to drive the innovations required. The long contracts are expected to drive private sector innovation, such that they create greater value while taking a lifecycle view of the project.

PPP projects require significant external involvement of the government and other stakeholders such that they get governed at multiple levels. Hence, besides the project level coordination, the external stakeholders also have to internally coordinate their proposed interactions with PPPs, increasing both the levels of interactions and the consequent complexity (Steijn, Klijn, & Edelenbos, 2011).

The presence of multi actors, further increases the number of possible communication and interaction channels, increasing complexity in PPPs. Further, the absence of a single central authority, as in the case of hierarchies, brings ambiguity in decisions making, increasing complexity (Klijn, 2007).

Koppenjan & Klijn (2004) argue that complexity comes from the absence of clear problem definitions and knowledge, such that it is contested; decisions requiring a wide variety of strategies in various arenas; and the decisions being embedded in complex institutional settings. All the above exist in plenty in PPPs, making them complex. Similarly, Van den Hurk & Verhoest (2015) have more recently argued that PPPs experience three kinds of complexities i.e., multi-actor complexity, technical complexity and political complexity.

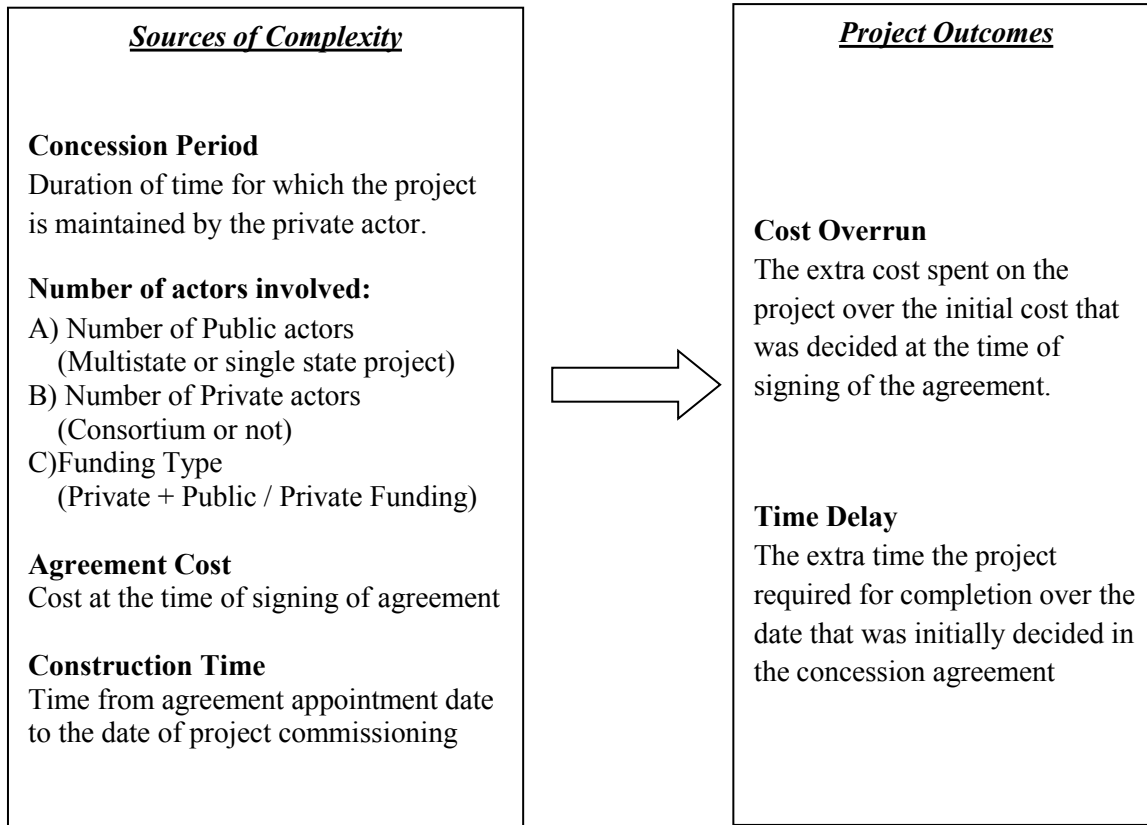


FIGURE 1: Hypothesized and Empirically Tested Model

Why does complexity affect performance?

The larger the number of actors and actions, interacting over long time frames, increases the behavioral and environmental uncertainty, which affects PPP performance. Uncertainties and need for frequent interactions increases the probability of deadlock happening – an equilibrium that has the character of a locked-in situation. Several actors employ different but conflicting strategies that act against each other and sustain the deadlock. And deadlocks result in suboptimal performance in PPPs.

Hence, we hypothesize that *PPP complexity leads to adverse performance implications.*

METHOD AND RESULTS

For empirically testing our hypothesis, we study the highway PPP sector in India. This sector has matured over one and a half decades. Over 660 highway projects have been taken up in India through the PPP route. We started with the database of over 1200 PPP projects in India. This list is available in the public domain (www.pppinindia.com/database.php) and is also the basis for the World Bank database (<http://ppi.worldbank.org/>). This list of projects was screened and after restricting ourselves to only road

projects (removing bridge constructions), and completed projects we are left with a list of 377 projects. We carefully scanned this data and were able to get complete information on 173 of these projects.

	Mean	Standard Deviation	Max	Min	Concession Period	State Presence	Consortium	Funding	Agreement Cost	Construction Time	Time Delay
Concession Period	219.601	69.636	390	60	1						
State Presence	0.947	0.222	1	0	-0.073 (0.059)	1					
Consortium	0.017	0.130	1	0	-0.008 (0.830)	0.058 (0.130)	1				
Funding	0.479	0.501	1	0	-0.256 (0.000)	0.028 (0.463)	-0.044 (0.254)	1			
Agreement Cost	319.693	392.972	2537	5.7	0.056 (0.144)	-0.073 (0.057)	-0.032 (0.411)	0.027 (0.484)	1		
Construction Time	723.323	312.910	2676	181	0.027 (0.487)	0.023 (0.539)	-0.042 (0.276)	-0.019 (0.625)	-0.019 (0.612)	1	
Time Delay	139.651	378.223	2376	-536	0.136 (0.000)	-0.019 (0.618)	-0.074 (0.054)	-0.028 (0.461)	-0.004 (0.907)	0.064 (0.096)	1
Cost Overrun	117.764	263.021	2499	-51.01	0.141 (0.000)	-0.086 (0.025)	-0.094 (0.015)	-0.057 (0.138)	0.170 (0.000)	0.011 (0.765)	-0.057 (0.881)

Note: The p-value of the correlation coefficient is provided in parenthesis.

TABLE 1: Descriptive statistics of the variables studied.

Complexity is a multidimensional concept. Motivated by the literature survey above, we view the complexity of PPPs to come from

- Size of the project: As project size increases (involving higher project costs) it includes more number of activities and hence the project becomes more complex. Agreement costs, in terms of the project cost specified at the agreement time, is used as a proxy for the project size complexity.
- Time for construction: Projects that are more complex require larger number of activities to be coordinated and managed, needing longer construction time. The construction time for the project is used as a measure of time based complexity.
- Number of actors involved(i): Highway projects are linear in nature and land acquisition is a major issue in Indian highway projects. If a project passes through multiple States it would require negotiating with different State actors for acquiring land for the project, increasing the project's complexity level. Hence, the passage of a project through multiple states increase its complexity. This is captured as a dummy variable i.e., state presence which is 0 for a project lying in one state and 1 for a project passing through more than one states.
- Number of actors involved (ii): One firm often does have all the competencies required for managing a PPP project and hence concessionaires consist of consortium of private players. As the number of private players in a consortium increase they are required to coordinate their activities with one another increasing complexity level of project. We capture this as 0 for a consortium and 1 for a single private actor.
- Number of actors involved (iii): Funding of highway projects is sometimes partially provided by the government. Hence, the concessionaire is required to regularly liaison with the government to seek

funds for project construction. We capture this as 0 for projects which involve some element of public contribution, and 1 for projects which are fully privately funded.

As a performance measure we consider the time and cost overruns in the project. We get mixed results in support for our core hypothesis regarding the impact of complexity on PPP performance (i.e., time and cost delays), in the empirical results summarized in Table 2. We ran OLS regression predicting construction time delays and cost over runs by the various complexity measures. We find the length of concession period, and the agreement cost have significant effects on project time delays. Hence, we can safely conclude that projects with long concession period, though themselves insignificantly correlated at 0.06 level with agreement cost, independently increase complexity of PPP projects, bringing about time delays in construction. On the other hand, we find state presence and agreement costs to significantly predict the cost over runs in the project. Presence of a project over multiple states, adds to the well-recognized complexity in land acquisition in the Indian context, with agreement costs significantly predicting cost over runs in PPP projects.

Variables	Time Delay	p-value	Cost Overrun	p-value
Concession Period	1.062 (0.473)	0.026	-0.052 (0.238)	0.827
State Presence	37.521 (138.497)	0.787	212.544 (69.605)	0.002
Consortium	-54.978 (222.464)	0.805	153.946 (112.258)	0.172
Funding	5.923 (60.231)	0.922	-11.449 (30.238)	0.705
Agreement Cost	0.153 (0.088)	0.084	0.487 (0.043)	0.00
Construction Time	-0.100 (0.103)	0.333	0.043 (0.052)	0.410
CONSTANTS	-55.090 [467.796]	0.00	398.860 [224.400]	0.00
Observations	173		173	
R-Squared	0.067		0.509	

Note: The standard errors are given in parenthesis.

TABLE 2: Relation between complexity and performance parameters.

DISCUSSION

The complexity in PPPs has been recognized for long. However, the empirical studies attempting to link complexity with PPP performance have not been conclusive. For instance, Klijn & Koppenjan (2016) survey PPP managers to find the impact of contract characteristics on performance of PPPs but find little support for the impact of PPP complexity, PPP flexibility, and renegotiations. They only find that the provision of sanctions (disciplining clauses) in PPP contracts to have performance impacts. Similarly, Singh (2010) analyzed the time and cost overruns of 894 Indian infrastructure projects, but found little support for the impact of complexity on project performance. Hence, our mixed findings are in line with existing studies.

Recent literature has however been arguing and empirically attempting to test the intervening role of management practices in PPPs (Steijn, Klijn, & Edelenbos, 2011). Significantly, Steijn, Klijn, & Edelenbos (2011) in their survey of about 200 Dutch managers find that although the degree of PPP correlates with that project outcomes, these are more on account of the managerial strategies deployed, with direct performance impact of nature of projects (complexity levels in PPPs).

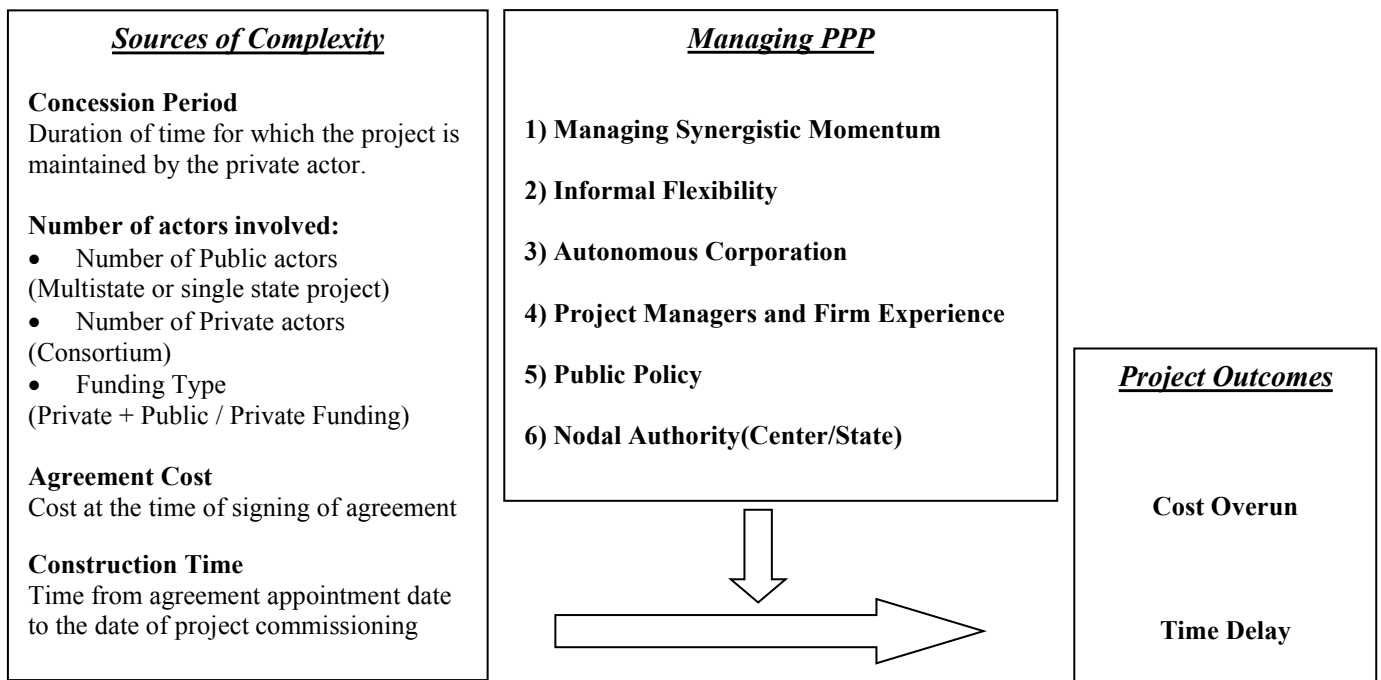


FIGURE 2: Model to be tested in future studies

Paper	Sample	Argument and Finding
Mahalingam, Devkar & Kalidindi, (2011)	Three comparative case studies in India. Sanitation sector	Administrative experience in handling project structuring and bid process, PPP specific expertise, understanding of PPP risks, are necessary but not sufficient condition for project success. Coordination agencies involvement is required over the full life cycle of the project.

Paper	Sample	Argument and Finding
Klijn & Teisman (2003)	Three comparative case studied in Netherlands. Railway sector -- Stations	PPPs idea get diluted. In the face of difficulty in decisions making and organizational coordination, partners revert to the traditional forms of contracting out and separating responsibilities.
Mistarihi, Hutchings, & Shacklock. (2013)	Two case studied in Jordan , Airports based on interviews	Identify key issues as lack of experienced workforce, existence of interplay of internal and external factors. Management strategies identified as important are human resource management practices, effective monitoring, and management of institutional differences.
Koppenjan, Veeneman, Van der Voort, Ten Heuvelhof, & Leijten (2011)	One large Netherlands rail project	The simultaneous requirements of project control and complexity have to be addressed for PPP project success
Steijn, Klijn, & Edelenbos, (2011)	Survey of Dutch environmental projects	The degree of PPP correlates with the project outcomes but is mediated by the management strategies used (16 items -- communication, involving external people, leadership style of consulting, relationship emphasis, continuous negotiations and discussion etc)
Klijn, Edelenbos, Kort, & van Twist, (2008)	Survey of 32 managers in 18 complex decision making projects in Netherlands	Though managers are faced by dilemmas but these are not either or choices, but rather simultaneous management of both.
Klijn & Koppenjan (2016)	144 respondents in 68 PPP projects in Netherlands	Contractual complexity , Flexibility, Sanctioning and length affect PPP performance. Only support for sanctioning ability found.
Jones, R., & Noble, G. (2008)	7 PPP projects in UK and Australia	PPP Managers as boundary spanners use informal and flexible personal- level agreements to progress PPPs
van den Hurk, M., & Verhoest, K. (2015).	A large sports project in Belgium	PPP complexity (technical, political and multi-actor) affects PPP performance, and the complexity of PPP governance (by bundling and mandating are not a solution for addressing this complexity.

TABLE 3: Review of literature on management of PPPs

Furthermore, numerous other management approaches for management of complexity in PPPs have also been identified. For a survey of relevant literature on the subject see table 3. The diverse literature on developmental economics, public policy, and project management contributes to this stream of literature, which makes prescriptions of how PPP need to be managed to improve their performance. Accordingly, we feel that our hypothesized direct relationship between PPP complexity and PPP performance would be moderated by the adoption of managerial approaches. Some of the managerial practices which have been identified in the literature include, simultaneously addressing the need for building in flexibility and also emphasizing control in large infrastructural projects (Koppenjan, Veeneman, Van der Voort, ten heuvelhof & Leijten (2011); making managerial choices, or more importantly managing various dilemma simultaneously (Klijn, Edelenbos, Kort, & van Twist, 2008 ; Mistarihi, Hutchings, & Shacklock, 2013) ; maintaining synergistic momentum and informal flexibility by the boundary spanners in PPPs (Jones & Noble, 2008) ; use of coordination modes (Garg, 2012); nature of coordination agencies (Mahalingam, Devkar & Kalidindi, 2011) ; project managers and firms experience and nature of experience (Garg, 2012) ; and internal versus external orientation or autonomous, cooperation or intermediating roles of the actors (Verweij, 2015). However, most of this research is either case based or very small sample based (20-40 survey respondents). Hence, further research is required to firstly identify the relevant management approaches in the PPP context, and then test out its performance implications in managing PPP complexity using a large sample.

CONCLUSION

This paper seeks to shift the PPP discourse from PPP formation to PPP implementation. To be able to make this shift, the discourse would also be required to fundamentally move from the dominant thinking about risk management to complexity management. That is, the view that PPP are innovative mechanisms for managing risk, need to be substituted with PPPs as innovative mechanisms for managing complexity. Some preliminary empirical results give evidence of how PPP complexity has performance implications are also presented, underscoring the performance impacts of PPP complexity. Our empirical results (so far) are quite in line with other similar studies (Klijn & Koppenjan, 2016 ; Singh, 2010) .

The primary contribution of this a study as work in progress, lies in identifying an important empirical context for study of complexity in PPPs in highways in a developing economy context, while focusing on a relatively mature sector of Highway PPPs. This paper lays out a foundation for us to examine the impact of managerial strategies in managing PPP complexities, which we propose to embark upon basing ourselves on the empirical study here and the literature survey on the management practices identified in a distributed literature, and having being identified as being effective piecemeal.

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